NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
IRRIGATION WATER CONVEYANCE
(FT)
HIGH-PRESSURE, UNDERGROUND, PLASTIC PIPELINE
CODE 430DD

DEFINITION

A pipeline and appurtenances installed in an irrigation system.

SCOPE

This standard applies to underground thermoplastic pipelines ranging from 1/2 in. to 18 in. in diameter that are closed to the atmosphere and that are subject to internal pressure of 80 lb/in2 or greater.

The standard includes the design criteria and minimum installation requirements for high-pressure, plastic irrigation pipelines and specifications for the thermoplastic pipe.

PURPOSE

To prevent erosion or loss of water quality of damage to the land, to make possible proper management or irrigation water, and to reduce water conveyance losses.

CONDITIONS WHERE PRACTICE APPLIES

All pipelines shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies, water quality, and rates of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application method to be used.

Plastic pipelines installed according to this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

Quantity

1. Effects on components of the water budget, especially infiltration and evaporation.

2. Effects on downstream flows or aquifers that would affect other water uses or users.

3. Potential use of irrigation water management.

4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

Quality

1. Effects of installing the pipeline, replacing other types of conveyances, on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.

3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.

4. Effects on wetlands or water-related wildlife habitats.

5. Effects on the visual quality of water resources.

DESIGN CRITERIA

Working pressure and flow velocity

The minimum acceptable class of pipe shall be that having a pressure rating for water of 80 lb/in2.

The pipeline shall be designed to meet all service requirements without an operating pressure, including hydraulic transients, or static pressure at any point greater than the pressure rating of the pipe used at that point. As a safety factor against surge or water hammer, the working pressure should not exceed 72 percent of the pressure rating of the pipe, nor should the design flow velocity at system capacity exceed 5 ft/s. If either of these limits is exceeded, special consideration must be given to the flow conditions and measures taken to adequately protect the pipeline against surge.

Capacity

The design capacity of the pipeline shall be based on whichever of the following criteria is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.

2. The capacity shall be sufficient to provide an adequate stream for all methods of irrigation planned.

Friction losses

For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient, c, equal to 150.

Outlets

Appurtenances required to deliver water from the pipeline to an individual sprinkler or to a lateral line of sprinklers or surface pipe located on the ground surface shall be known as outlets. Outlets shall have adequate capacity to delivery the design flow to the individual sprinkler, surface lateral line of sprinklers, or surface pipe at the design operating pressure.

Check valves

A check valve shall be installed between the pump discharge and the pipeline where backflow may occur.

Pressure-relief valves

A pressure-relief valve shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. Pressure-relief valves shall be installed on the discharge side of the check valve where a reversal of flow may occur and at the end of the pipeline if needed to relieve surge at the end of the line.

Pressure-relief valves shall be no smaller than 1/4-in. nominal size for each inch of the pipeline diameter and shall be set to open at a pressure no greater than 5 lb/in.2 above the pressure rating of the pipe.

The pressure at which the valves start to open shall be marked on each pressure-relief valve. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Manufacturers or pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

Air-release valves

The three basic types of air-release valves for use on irrigation pipelines are described below:

An air-release valve, a continuously acting valve that has a small venting orifice, generally ranging between 1/16 and 3/8 in. in size. This valve releases pockets of air from the pipeline once the line is filled and under working pressure.

An air-and-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling and allows air to reenter the line and prevents a vacuum from forming during emptying. This type of valve is sometimes called air-vacuum-release valve or air-vent-and-vacuum-relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

A combination air valve is sometimes called a combination air-release and air-vacuum valve or combination air-and-vacuum-relief valve. It is continuous acting and combines the functions of both and air-release valve and the air-and-vacuum valve. Both valves are housed in one valve body.

If needed to provide positive means for air escape during filling and air entry while emptying, air-and-vacuum valves or combination air valves shall be installed at all summits, at the entrance, and at the end(s) of the pipeline. Such valves generally are needed at these locations if the line is truly closed to the atmosphere. However, they may not be needed if other features of the pipe system, such as permanently located sprinkler nozzles or other unclosed service outlets, adequately vent the particular location during filling and emptying operations.

The ratio of air-release valve diameter to pipe diameter for valves intended to release air when filling the pipe should not be less than 0.1. However, small-diameter valves may be used to limit water hammer pressure by controlling air release where control of filling velocities is questionable. Equivalent valve outlet diameters of less than 0.1 are permitted for continuously acting air release valves. Adequate vacuum relief must be provided.

Air-release valves or combination air valves shall be used as needed to permit air to escape from the pipeline while the line is at working pressure. Small orifices of these types shall be sized according to the working pressure and venting requirements recommended by the valve manufacturer.

Manufacturers of air valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selection and acceptance of these valves.

Drainage

Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures, drainage is

recommended by the manufacturer of the pipe, or drainage of the line is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping or by other means.

Flushing

If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

Thrust control

Abrupt changes in pipeline grade, horizontal alinement, or reduction in pipe size normally require an anchor or thrust blocks to absorb any axial thrust of the pipeline. Thrust control may also be needed at the end of the pipeline and at inline control valves.

Thrust blocks and anchors must be large enough to withstand the forces tending to move the pipe, including those of momentum and pressure as well as forces due to expansion and contraction.

The pipe manufacturer's recommendations for thrust control shall be followed. In absence of the pipe manufacturer's requirements, the following formula must be used in designing thrust blocks:

$$A = \frac{98 \; HD^2}{B} \sin\frac{a}{2}$$

Where:

A=Area of thrust block required in ft2
H=Maximum working pressure in ft
D=Inside diameter of pipe in ft
B=Allowable passive pressure of the soil in lb/ft2
a=Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90-deflection angle of pipe bend.

If adequate soil tests are not available, the passive soil pressure may be estimated from table 1.

Materials

All materials shall meet or exceed the minimum requirements indicated in "Specifications for Materials."

PLANS AND SPECIFICATIONS

Plans and specifications for constructing high-pressure underground plastic pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Table 1 - Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3ft	4ft	5ft
		lb/ft2		
Sound bedrock.....	8000	10000	10000	10000
Dense sand and gravel mixture (assumed o= 40 deg).....	1200	1800	2400	3000
Dense fine to coarse sand (assumed o= 35 deg).....	800	1200	1650	2100
Silt and clay mixture (assumed o=25 deg).	500	700	950	1200
Soft clay and organic soils (assumed o=10 deg).....	200	300	400	500

INSTALLATION

Minimum depth of cover

Pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossings, farming operations, freezing temperatures, or soil cracking. The minimum depth of cover for pipe susceptible to any of these hazard shall be:

Pipe diameter	Depth of cover
in.	in.
1/2 through 2 1/2	18
3 through 5	24
6 or more	30

In areas where the pipe will not be susceptible to freezing and vehicular or cultivation hazards and the soils do not crack

appreciably when dry, the minimum depth of cover may be reduced to:

Pipe diameter	Depth of cover
in	in
1/2 through 1 1/2	6
2 through 3	12
4 through 6	18
More than 6	24

In cranberry bogs where the pipe is not susceptible to freezing and heavy equipment is never allowed, the minimum depth of cover may be 6 in. for a 6-in. diameter pipe and 12 in. for a larger pipe.

The minimum cover for polyehylene pipe is 6 in. but may be reduced to 2 in. where conditions warrant. The minimum cover for PVC pipe in cranberry bogs, where the pipe is to be protected from freezing after winter flooding, shall be 12 in., if the winter flood equals or exceeds 12 in., or the depth that will place the top of the pipe at least 24 in. below the water surface where the winter flood is less than 12 in. Solvent-welded joints shall be used at all connections of PVC pipe where peat and muck exist in their normal layered pattern. Rubber gasket joints may be used following normal bedding procedures where coarse sand or cement layers exist.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. The top width of the fill shall then be no less than 10 ft and the side slopes no steeper than 6:1: If extra protection is needed at vehicle crossings, encasement pipe or other approved methods may be used.

Trench construction

The trench at any point below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be uniformly placed under the haunches and along sides of the pipe. The maximum trench width shall be 36 in.

If the trench is precision excavated and has a semicircular bottom that closely fits the pipe, the width shall not exceed the outside diameter of the pipe by more than 10 percent.

The trench bottom shall be uniform so that the pipe lays on the bottom without bridging. Clods, rocks, and uneven spots that can damage the pipe or cause nonuniform support shall be removed.

If rocks, boulders, or any other material that can damage the pipe are encountered, the trench bottom shall be undercut a

minimum of 4 in. below final grade and filled with bedding material consisting of sand or compacted fine-grained soils.

Pipelines having a diameter of 1/2 through 2 1/2 in. that are to be placed in areas not subject to vehicular loads and in soils that do not crack appreciable when dry may be placed by using "plow-in" equipment instead of conventional trenching.

Provisions shall be made to insure safe working conditions where unstable soil, trench depth, or other conditions can be hazardous to personnel working in the trench.

Provisions shall be made to insure safe working conditions where unstable soil, trench depth, or other conditions can be hazardous to personnel working in the trench.

Placement

Care shall be taken to prevent permanent distortion and damage when handling the pipe during unusually warm or cold weather. The pipe shall be allowed to come within a few degrees of the temperature it will have after it is completely covered before placing the backfill, other than that needed for shading, or before connecting the pipe to other facilities. The pipe shall be uniformly and continuously supported over its entire length on firm stable material. Blocking or mounding shall not be used to bring the pipe to final grade.

For pipe with bell joints, bell holes shall be excavated in the bedding material, as needed, to allow for unobstructed assembly of the joint and to permit the body of the pipe to be in contact with the bedding material throughout its length.

Joint and connections

All joints and connections shall be designed and constructed to withstand the design maximum working pressure for the pipeline without leakage and to leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

All fittings, such as coupling, reducers, bends, tees, and crosses, shall be installed according to the recommendations of the pipe manufacturer.

Fittings made of steel or other metals susceptible to corrosion shall be adequately protected by being wrapped with plastic tape or by being coated with a substance that has high corrosion-preventative qualities. If plastic tape is used, all surfaces shall be thoroughly cleaned and coated with a primer compatible with the tape before wrapping.

Thrust blocks

Thrust blocks must be formed against a solid hand-excavated trench wall undamaged by mechanical equipment. They shall be constructed of concrete, and the space between the pipe and trench wall shall be filled to the height of the outside diameter of the pipe or as specified by the manufacturer.

Testing

The pipeline shall be tested for pressure strength, leakage, and proper functioning. The tests may be performed before backfilling or anytime after the pipeline is ready for service.

Tests for pressure strength and leaks shall be accomplished by inspecting the pipeline and appurtenances while the maximum working pressure is maintained and all joints and connections are uncovered, or by observing normal operation of the pipeline after it is put into service. Partial backfills needed to hold the pipe in place during testing shall be placed as specified in "Initial Backfill." Any leaks shall be repaired and the system retested.

The pipeline shall be tested to insure that it functions properly at design capacity. At or below design capacity there shall be no objectionable flow conditions. Objectionable flow conditions shall include water hammer, continuing unsteady delivery of water, damage to the pipeline, or detrimental discharge from control valves.

Initial backfill

Hand, mechanical, or water packing methods may be used.

The initial backfill material shall be soil or sand that is free from rocks or stones larger than 1 in. in diameter. At the time of placement, the moisture content of the material shall be such that the required degree of compaction can be obtained with the backfill method to be used. The initial backfill material shall be placed so that the pipe will not be displaced, excessively deformed, or damaged.

If backfilling is done by hand or mechanical means, the initial fill shall be compacted firmly around and above the pipe as required to provide adequate lateral support to the pipe.

If the water packing method is used, the pipeline first shall be filled with water. The initial backfill before wetting shall be of sufficient depth to insure complete coverage of the pipe after consolidation. Water packing is accomplished by adding enough water to diked reaches of the trench to thoroughly saturate the initial backfill without excessive pooling. After the backfill is saturated, the pipeline shall remain full until after the final backfill is made. The wetted fill shall be allowed to dry until firm before beginning the final backfill.

Final backfill

The final backfill material shall be free of large rocks, frozen clods, and other debris greater than 3 in. in diameter. The material shall be placed and spread in approximately uniform layers so that there will be no unfilled spaces in the backfill and the backfill will be level with the natural ground or at the design grade required to provide the minimum depth of cover after settlement. Rolling equipment shall not be used to consolidate the final backfill until the specified minimum depth of cover has been placed.

All special backfilling requirements of the pipe manufacturer shall be met.

Basis of acceptance

The acceptability of the pipeline shall be determined by inspections to check compliance with all the provisions of this standard with respect to the design of the line, the pipe, and pipe marking, the appurtenances, and the minimum installation requirements.

Certifications and guarantee

If requested by the state conservation engineer, a qualified testing laboratory must certify with supporting test results that the pipe meets the requirements specified in this standard. The seal of approval of a recognized laboratory on pipe bearing one of the ASTM designations listed in this standard may be accepted for this certification.

The installing contractor shall certify that his installation complies with the requirements of this standard. He shall furnish a written guarantee that protects the owner against defective workmanship and materials for not less than 1 year. The certification identifies the manufacturer and markings of the pipe used.

MATERIALS

Quality of plastic pipe

The compound used in manufacturing the pipe shall meet the requirements of one of the following materials:

1. Polyvinyl chloride (PVC) as specified in ASTM-D-1784.

Material	Code classification
Type I, Grade 1	12454-B
Type I, Grade 2	12454-C
Type III, Grade 1	14333-D

2. Acrylonitrile-butadiene-styrene (ABS) as specified in ASTM-D-1788.

Material	Code classification
Type I, Grade 2	5-2-2
Type I, Grade 3	3-5-5
Type II, Grade 1	4-4-5

3. Polyethylene (PE) as specified in ASTM-D-1248.

Material	Code classification
Grade P14, Class C	IC-P14
Grade P23, Class C	IIC-P23
Grade P33, Class C	IIIC-P33
Grade P34, Class C	IVC-P34

The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign matter, or other defects. The pipe shall be as uniform in color, opacity, density, and other physical properties as is commercially practicable.

Pipe requirements

All pipe installed under this standard shall be pressure rated for water.

The relationship between standard dimension ratios, dimensions, hydrostatic design stresses, and pressure ratings shall be determined by one of the following formulas:

For PVC, ABS, and PE pipe with outside diameter controlled:

$$\frac{2S\ Do}{P\ t} - 1 \quad \text{or} \quad \frac{2S}{P} = R - 1$$

For PE pipe with inside diameter controlled:

$$\frac{2S}{P} = \frac{Di}{t} + 1 \text{ or } \frac{2S}{P} = R + 1$$

Where:

S=hydrostatic design stress in lb/in.2
P=pressure rating in lb/in.2
Do=average outside diameter in in.
Di=average inside diameter in in.
t=minimum wall thickness in in.
R=standard thermoplastic pipe dimension ratio (SDR)

Hydrostatic design stresses for the plastic pipe material are given in table 1.

Iron pipe (IPS) (outside diameter same as that for iron pipe sizes) and I.D. controlled PE pipe manufactured, tested, and marked to meet one of the following ASTM specifications shall be acceptable under this standard. Water pressure ratings and pertinent dimensions for this pipe are given in tables 3, 4, 5, 6 and 7.

ASTM-	Standard specification for-
ASTM-	Standard specification for-
D-1785	Polyvinyl chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
D-2241	Polyvinyl chloride (PVC) Plastic Pipe, (SDR-PR)
D-2672	Bell-End Polyvinyl chloride (PVC) Pipe
D-2740	Polyvinyl chloride (PVC) Plastic Tubing
D-1527	Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80
D-2282	Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe (SDR-PR)
D-2104	Polyethylene (PE) Plastic Pipe, Schedule 40
D-2239	Polyethylene (PE) Plastic Pipe, (SDR-PR)
D-2447	Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, based on outside diameter
D-2737	Polyethylene (PE) Plastic Tubing
D-3035	Polyethylene (PE) Plastic Pipe, (SDR-PR), based on controlled outside diameter

Plastic irrigation pipe (PIP) shall meet the requirements of ASTM-D-2241 or of ASTM-D-2282 except that:

1. The outside diameters, wall thicknesses, and tolerances given in table 2 shall apply.

2. The sustained pressure test shall not be required.

3. The burst pressure tests shall be performed according to the procedures listed in ASTM-D-2241 or D-2282 and shall meet the applicable requirements given in these ASTM's or those listed below for the standard dimension ratios (SDR's) currently not included in ASTM-D-2241 or D-2282.

Burst pressure requirements for water at 23 degrees C (73.4 degrees F) for PVC 1120 and PVC 1220 plastic pipe are:

SDR	Minimum burst pressure1
	lb/in2
51	260

1The design stress levels used to derive these test pressures are: PVC 1120-6,400 lb.in.2; PVC 1220-6,400 lb/in2.

Burst pressure requirements for water 23 degrees C (73.4 degrees F) for ABS plastic pipe are:

	Minimum burst pressure 1	
SDR	ABS2112	ABS1316
	lb/in.2	lb/in.2
32.5	420	380
41	-	300

1The fiber stresses used to derive these test pressures are: ABS 2112-6,600 lb/in2 ABS 1316-6,000 lb/in.2. To simplify testing, minor adjustments have been made to keep the test pressures uniform.

Markings

Markings on the pipe shall include the following, which shall be spaced at intervals of not more than 5 ft:

1. Nominal pipe size (for example, 2 in.).

2. Type of plastic pipe material, by designation code (for example, PVC 1120)

3. Pressure rating, in lb/in2, for water at 23 deg C (73.4 deg. F) (for example, 160 lb/in.2).

4. Specification designation with which the pipe complies:

   a. For IPS-size pipe, the ASTM designation (for example, D-2241).

      Pipe meeting one of the ASTM designations listed for IPS-size pipe and intended for the transport of potable water shall also be marked with the seal of a recognized laboratory making the evaluation for this purpose.

   b. For plastic irrigation pipe, the designation PIP.

5. Manufacturer's name (or trademark) and code.

Fittings and couplers

All fittings and couplers shall meet or exceed the same strength requirements as those of the pipe and shall be made of material that is recommended for use with the pipe.

Listed below are the ASTM standard specifications for fittings suitable for use with IPS-size pipe and inside diameter controlled PE pipe covered by this standard:

ASTM-	Standard Specification for-
D-2466	Socket type Polyvinyl chloride (PVC) Plastic Pipe Fittings, Schedule 40
D-2467	Socket type Polyvinyl chloride (PVC) Plastic Pipe Fittings, Schedule 80
D-3036	Polyvinyl chloride (PVC) Plastic Line Couplings, Socket type
D-2468	Socket type Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Fittings, Schedule 40
D-2469	Socket-type Acrylonitrile-Butadiene-Styrene (ABS) Plastic Fittings, Schedule 80
D-2069	Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
D-2611	Butt Fusion Polyethylene (PE) Plastic Pipe Fittings, Schedule 80 (for IPS Pipe)
D-2610	Butt Fusion Polyethylene (PE) Plastic Pipe Fittings, Schedule 80 (for IPS Pipe)

D-2683	Socket type Polyethylene Fittings for SDR 11.0 Polyethylene Pipe
D-3139	Standard Specification for Plastic Pressure Pipe using Flexible Elastomeric Seals

Plastic irrigation pipe (PIP) shall have belled ends or separate couplers and fittings that are suitable for joining the pipe and appurtenances by solvent cement, rubber gaskets, or other methods recommended by the pipe manufacturer. Such fittings and joints shall be capable of withstanding a working pressure equal to or greater than that for the pipe.

Solvent cement joints

Solvent for solvent cement joints shall conform to ASTM Specification D-2564 for PVC pipe and fittings and to D-2235 for ABS pipe and fittings. Solvent cement joints shall be used and constructed according to the recommendations of the pipe manufacturer.

Rubber gasket joints

Rubber gasket joints shall conform to ASTM Specification D-3139.

Table 1. Hydrostatic design stress and designation-plastic pipe

Plastic pipe material	Hydrostatic design stress	Designation
	lb/in2	
PVC Type I, Grade 1	2,000	PVC 1120
PVC Type I, Grade 2	2,000	PVC 1220
PVC Type II, Grade 1	1,000	PVC 2110
PVC Type II, Grade 1	1,250	PVC 2112
PVC Type II, Grade 1	1,600	PVC 2116
ABS Type I, Grade 2	800	ABS 1208
ABS Type I, Grade 2	1,000	ABS 1210
ABS Type I, Grade 3	1,600	ABS 1316
ABS Type II, Grade 1	1,250	ABS 2112
PE Grade P14	400	PE 1404
PE Grade P23	500	PE 2305
PE Grade P23	630	PE 2306
PE Grade P33	630	PE 3306
PE Grade P34	630	PE 3406
PE Grade P34	800	PE 3408